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Six-fold suture:wound length ratio for abdominal closure

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Midline laparotomy incision is generally closed as a continuous single layer with monofilament suture. To achieve safe abdominal closure, it is advised to have a suture:wound length (SL:WL) ratio of more than 4:1. The importance of a high SL:WL ratio led us to standardise a safe abdominal closure technique. We calculated the subsequent SL:WL ratio and support our finding with a mathematical model.

Between March 1996 and February 1997, 100 consecutive patients undergoing elective or emergency laparotomy through a midline incision were entered into this prospective study. The wounds were closed with a single layer continuous suture to approximate the abdominal muscles. Suture and wound lengths were recorded. Patients were followed for one year.

Five patients developed incisional hernia at 12 months postoperatively. There was no burst abdomen. The mean SL:WL ratio: was 6.2:1. A mathematical model confirms that a SL:WL ratio of 6:1 should be achieved with this suture technique.

We recommend an optimal SL:WL ratio: greater than or equivalent to 6:1 to achieve safe closure of midline laparotomy incision.

Key words: Laparotomy incision (midline) – Suture:wound length ratio

Midline laparotomy wounds are generally closed as a continuous single layer with monofilament suture.[1] The midline incision has been reported to have a significantly higher incidence of incisional hernia and burst abdomen.[2] Burst abdomen is an avoidable complication and, with safe abdominal closure, it is possible to have an acceptable incidence of incisional hernia.

Jenkins was the first to advise that vertical abdominal incision closure is safe if a suture:wound length (SL:WL) ratio of more than 4:1 is achieved for wounds closed in layers.[3] Since then, several reports in

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support of Jenkins' observation have been published.[2,4–6] Jenkins gave a rational explanation for the high SL:WL ratio based on mathematical and clinical studies.[3] Size of the tissue bites bears an inverse relationship to the distribution of forces at the suture–tissue interface, hence, large bites have less tendency to cut through.[7] Also, inflammatory changes during healing extend to about 5 mm from the cut edge.[8] The importance of a high SL:WL ratio led us to standardise a safe abdominal closure technique using monofilament suture as continuous single layer with 1 cm tissue bites on either side and at 1 cm intervals. The SL:WL ratio was calculated to determine optimal SL:WL ratio for achieving safe abdominal closure.

Patients and Methods

Between March 1996 and February 1997, 100 consecutive patients undergoing elective or emergency laparotomy through midline incision were entered into this prospective study. Patients with incisional hernia after previous midline laparotomy, life threatening haemorrhage, shock, jaundice, uraemia, or on steroid treatment were not entered into the study.

Personal, operative and follow-up details were entered into standard proformas. Personal details recorded were age, sex, past medical history, diagnosis, and urgency of the operation. The type and length of incision, operation done, type and length of sutures used were recorded in the operation details. The length of the incision was measured with a sterile steel ruler before closure.

Monofilament loop polydiaxanone (PDS), size number 1, on a 50 mm heavy, half circle round bodied needle (NW 9262, Ethicon, Bombay, India) was used for all closures. Closure was standardised to achieve a safe closure under minimal tension. During wound closure, the suture was held taut without tension. The wounds were closed as a continuous single layer, beginning at the top and bottom ends of the wound to complete the closure at the mid-point of the wound. Tissue bites (1 cm) were taken on either side at 1 cm intervals. All knots were buried and consisted of 5 throws. All left-over pieces of the PDS suture were collected and measured. Interrupted prolene or silk sutures were used for skin.

In calculating SL:WL ratio, the suture length for knotting and as free cut ends were subtracted from the overall suture length used. It was estimated that each knot would use 1 cm of suture and another centimetre of suture was left as free cut end. Thus provision of 2 cm was made for each knot.

The length of the suture used and the measured length of the wound were used to calculate the SL:WL ratio. The stitch interval was calculated as the ratio of the wound length to the number of stitches.

Antibiotics (cefuroxime and metronidazole) were given as per the following protocol. Clean cases had 3 doses of antibiotics, prophylactically. Clean-contaminated cases were given antibiotics for 3 days. Contaminated and dirty cases were treated with antibiotics for 5–7 days. The antibiotic course was prolonged if deemed necessary during the postoperative period. Other medical treatments were given as appropriate to the disease pathology, concomitant diseases, and recovery of the patient. All postoperative complications were recorded. All patients were followed-up at 1 month and 12 months and examined for incisional hernia, unless they were required to be seen at other times for other clinical reasons.

Incisional hernia was defined as a palpable defect in the linea alba or protusion of abdominal contents through a defect in the linea alba when the patient was examined lying supine, lifting both legs or coughing and straining while standing. Patients who were unable to attend at 12 months were sent a questionnaire.

Results

Between March 1996 and February 1997, 100 consecutive patients, undergoing midline laparotomy and fulfilling the protocol criteria were entered into this prospective study. There were 61 men. The mean age of patients was 41 years (range 11–69 years).

Table 1 List of various operations (n = *100*)

Operation	Number
Perforation peritonitis	23
Adhesiolysis	14
Small bowel resection anastomosis	14
Right hemicolectomy	10
Gastrojejunostomy and vagotomy	8
Stricturoplasty	4
Partial gastrectomy	4
Left hemicolectomy	3
Splenectomy	3
Hartmann's operation	2
Meckel's diverticulum excision	2
Oophorectomy	2
Repair liver tear	2
Exploratory laparotomy	2
Operation for faecal fistula	2
Hysterectomy	2
Total gastrectomy	1
Pancreatico cystogastrostomy	1
Ileo transverse anastomosis	1

Table 2 Degree of contamination and wound complications

Degree of contamination	No. operated	No. examined At 1 year	Wound infection		Incisional hernia	
			n	%	*n*	%
Clean	23	20	1	5	1	5
Clean contaminated	52	42	2	5	2	5
Contaminated	13	12	2	16	1	8
Dirty	12	11	3	27	1	9
Total	100	85	8	9	5	6

Follow-up at 1 month was 96% and at 1 year was 85%. Sixty patients were examined personally by the first author. Of those who failed to attend, 25 responded to the questionnaire. Fifteen patients were lost to follow-up at 12 months. Of the 100 laparotomies, 65 were elective operations and 35 were undertaken as emergencies. Diagnoses of these patients are shown in Table 1. Table 2 shows the percentages of clean, clean-contaminated, contaminated and dirty laparotomies, and the incidence of complications.

The mean stitch interval was 1 cm (range 0.9–1.1 cm) and mean SL:WL ratio was 6.2:1 (6:1–7:1).

There were no burst abdomen in our series. Our overall wound infection rate was 9% (Table 2).

At 12 months, incisional hernia was present in 5 patients. All of these patients had wound infection which responded to drainage and antibiotics. Three of these patients also had postoperative chest complications.

Discussion

Earlier surgeons chose the abdomen closure technique based on teaching, recommendation or personal experience. Dudley suggested the benefit from large tissue bites and thick sutures[7] for safe abdominal closure. Jenkins was probably the first to recommend a specific SL:WL ratio on the basis of clinical studies and mathematical calculations.[5] Jenkins gave a mathematical analysis to support this ratio derived from consideration of layered wound closure. For safe abdominal wall closure, it is generally recommended to have 1 cm tissue bites at 1 cm intervals of monofilament suture as continuous single layer under minimal tension.[1–4]

A high SL:WL ratio is recommended by many.[2–4] They all have recommended SL:WL ratio of greater than or equivalent to 4:1. It has been suggested that SL:WL ratio of > 5 might lead to increased incidence of wound infection, due to more suture (foreign body) in the wound.[6]

Abdominal closure should be done under minimal tension. Tissue entangled between sutures under tension develops poor circulation and impaired subsequent healing, leading to increased wound complications. Moreover, it has been shown that postoperative abdominal distension could increase the wound length by 30%.[3] Stitching under minimal tension with 1 cm tissue bites and 1 cm intervals, enables lengthening of the wound in cases of abdominal distension without the stitches cutting through the tissue and with good wound healing. Based on these recommendations and

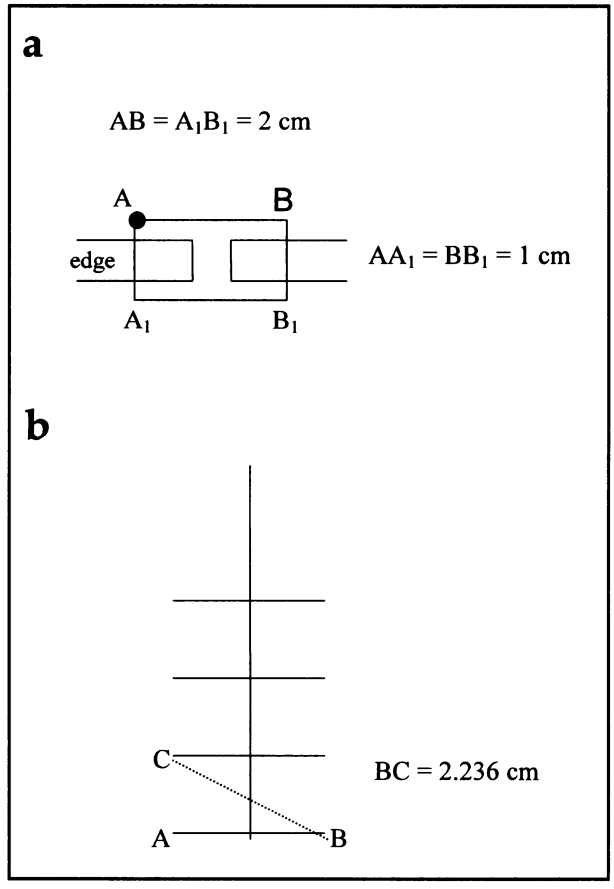

Figure 1 The mathematical model of wound closure: (**a**) the cross sectional view; (**b**) the view from the front. Horizontal limb = AB = A_1B_1 = 2 cm. Diagonal = BC = 2.236 cm. Vertical limb (depth) = AA_1 = BB_1 = 1 cm. Stitch interval = AC = 1 cm

recognising the importance of high SL:WL ratio, we tried to standardise the technique for safe single layer closure of midline laparotomy incision. We then measured the resulting SL:WL ratio.

In our series, there was no burst abdomen. Burst abdomen is an avoidable complication and is rarely seen nowadays because of proper sutures and closure technique.[2–4]

The aim of our study was not to evaluate the efficacy of different abdominal closure techniques to prevent wound complications, but to determine the SL:WL ratio resulting from standardising the abdominal closure technique. However, having achieved a high SL:WL ratio, we observed a relatively low incidence of incisional hernia. Up to 10% of abdominal incisions will develop incisional hernia.[9] In this study, 5% of incisions developed incisional hernia. The incidence of incisional hernia may have been under-reported as we could personally examine only 60% of the patients and moreover 15% of patients were lost to follow-up.

Our SL:WL ratio varied from 6:1 to 7:1 with a mean ratio of 6.2:1. The SL:WL ratio depends on the size of tissue bites, stitch interval and the tension on the suture. There are very few studies to suggest the importance of these factors on wound healing.[10]

We support our finding with a mathematical model (Fig. 1). The wound is three dimensional and hence suture length is required for the third dimension or depth (see Fig. 1a). This dimension was ignored by Jenkins.[3] If sutures are placed 1 cm from the edge, 1 cm apart, the horizontal limb = AB = A_1B_1 = 2 cm. We assume that the vertical limb (depth) = AA_1 = BB_1 = 1 cm. The stitch interval AC = 1 cm. Therefore, length of suture from A to C > 6 cm. For each step of 1 cm along the wound, one diagonal is required (Fig. 1b). The diagonal BC = $\sqrt{(AB^2 + AC^2)}$ = $\sqrt{5}$ = 2.236 cm. Therefore, the total length of suture required = 6.236 per cm of wound, which is very close to the observed mean SL:WL ratio of 6.2.

We recommend an optimal SL:WL ratio greater than or equivalent to 6:1 to achieve safe single layer closure of midline laparotomy incisions, for the usual abdominal wall muscle thickness of 1 cm. A greater SL:WL ratio will be needed if the abdominal wall is thicker than 1 cm.

Our mathematical calculation is consistent with the belief that safe wound closure depends on careful technique, with tissue approximation without tension or compression of the tissues.

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